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HYDRAULIC TABLES

FOR THE

CALCULATION OF THE DISCHARGE

THROUGH

SEWERS, PIPES AND CONDUITS;

BASED ON KUTTER'S FORMULA.

By P. J. FLYNN, Civil Engineer.

REPRINTED FROM VAN NOSTRAND'S MAGAZINE.

NEW YORK:
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ERRATA.

Page 19, 9th line from top,

$$\frac{81.26}{5} = 16.252 \textit{ should be } \frac{81.24}{5} = 16.248.$$

Page 19, 5th line from bottom,

$$\frac{81.26}{1796.5} = .045232 \textit{ should be } \frac{81.24}{1796.5} = .045221.$$

Page 26, third column, 4th line from bottom, 1.558 *should be* 1.458.
" 30, fifth column, 4th line from bottom, 80216 *should be* 80916.
" 35, third column, bottom line, .121286 *should be* .121268.
" 48, second column, 6th line from bottom, .004081623 *should be* .004081633.
" 51, second column, 4th line from top, .008546099 *should be* .003546099.
" 64, second column, 8th line from top, .001136752 *should be* .002136752.
" 65, second column, 3d line from bottom, .092057613 *should be* .002057613.
" 66, third column, 4th line from top, .045085 *should be* .045033.
" 68, second column, 1st line from top, .001944246 *should be* .001934236.
" 68, second column, 2d line from top, .008930502 *should be* .001930502.
" 90, second column, 3d line from top, .001290190 *should be* .001209190.
" 112, 14th line from top, .03271 *should be* .03371.
" 133, second column, 2d line from top, 2.156 *should be* 3.156.
" 133, fifth column, 1st line from top, 203.98 *should be* 208.58.
" 134, second column, 6th line from bottom, 12.999 *should be* 11.999.

PREFACE.

The usefulness of such tables as are presented in the following pages requires no demonstration in a preface. A glance at the explanatory text and tabular arrangement of the values will be sufficient to convince the practical engineer, who has ever had occasion to apply Kutter's formula, that the present collection is in an eminent degree of the labor saving kind.

Editor of Magazine.

Hydraulic Tables Based on Kutter's Formula.

THE tables given below are intended to facilitate the calculation of velocities, discharges, slopes and dimensions of sewers and other conduits, and their use will effect a great saving of time; as, for instance, instead of calculating the velocity and discharge by the use of a troublesome formula, the same result, practically, will be arrived at by taking the product of two factors given in the tables.

Kutter's formula is a complicated equation, and in its general form is:

$$v=c\sqrt{rs} \text{ in which}$$

$$c=\left\{\frac{41.6+\frac{1.811}{n}+\frac{.00281}{s}}{1+\left((41.6+\frac{.00281}{s})\times\frac{n}{\sqrt{r}}\right)}\right\}$$

In this and the following formulæ,

v=mean velocity in feet per second.
c=coefficient of mean velocity.
s=fall of water surface (h) in any distance (l) divided by that distance= $\frac{h}{l}$=sine of slope.
r=hydraulic mean depth=area of cross section of water divided by wetted perimeter=$\frac{a}{p}$.
d=diameter of circular channel.
a=area of cross section of water.
p=wetted perimeter.
Q=discharge in cubic feet per second.
n=the natural coefficient depending on the nature of the bed, that is, the lining of the channel over which the water flows, which throughout this article, and in the preparation of the tables, has been taken at .015.

Mr. J. C. Trautwine, in his *Engineer's Pocket Book*, states that, "In consideration of the rough character of sewer brickwork generally," he has taken n= .015 in Kutter's formula when he calculated the velocities in sewers.

Mr. R. Hering, in a paper read before the American Society of Civil Engineers in 1878 on the velocity and discharge of sewers, gave:

" n=.015" for "foul and slightly tuberculated iron; cement and terra cotta pipes with imperfect joints, and in bad order; well dressed stonework and second-class brickwork." The tables do not apply to channels with smooth or plastered surfaces. They are intended to apply only to sewers, conduits and other channels whose surfaces exposed to the flow of water are of second-class brickwork, or have surfaces of other material equally rough, such, for instance, as those given above from Mr. Hering's paper.

The general form of Kutter's formula is:

$$v=c\sqrt{rs}=c\sqrt{r}\times\sqrt{s} \quad . \quad . \quad . \quad . \quad (1).$$

from which

$$c\sqrt{r}=\frac{v}{\sqrt{s}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

$$\sqrt{s}=\frac{v}{c\sqrt{r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3).$$

$$s=\left(\frac{v}{c\sqrt{r}}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

$$Q=av=ac\sqrt{r}\times\sqrt{s} \quad . \quad . \quad . \quad . \quad . \quad (5).$$

from which

$$a=\frac{Q}{v} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

$$ac\sqrt{r}=\frac{Q}{\sqrt{s}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

$$\sqrt{s}=\frac{Q}{ac\sqrt{r}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8).$$

$$s=\left(\frac{Q}{ac\sqrt{r}}\right)^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

The values of $c\sqrt{r}$ and $ac\sqrt{r}$ for 173 diameters are given in Table 1, and the values of $\sqrt{s}$ for 1072 slopes are given in Table 2. It will then be seen that a large range of channels numbering 185456 are included in these tables. The vélocity is found by the product of two factors $c\sqrt{r}$ and $\sqrt{s}$, and in a similar way the discharge is found by the product of the two factors $ac\sqrt{r}$ and $\sqrt{s}$.

In Kutter's formula given above the value of c is found from an equation in-

volving the value of r, n and s, so that any change in the value of s would cause a change in the value of c, but as the influence of s on the value of c is not very marked in such slopes as are usually adopted for sewers and conduits, the value of the coefficient has been calculated for one slope, that of 1 in 1000 or $s = .001$. This value of the coefficient is *practically constant* for all values of s with a steeper slope than 1 in 1000, and as sewers are generally designed with steeper slopes than 1 in 1000, the tables are well adapted to facilitate the calculations. For flatter slopes than 1 in 1000 up to even 2 feet per mile, or 1 in 2640, the tables give results showing a maximum error in the case of a sewer 2 feet in diameter of less than 2 per cent., and in the case of a sewer 8 feet in diameter less than $\frac{1}{2}$ per cent.; therefore, for all practical purposes, the tables are sufficiently accurate.

The hydraulic mean depth of a cylindrical conduit flowing full is equal to one-fourth of the diameter.

The *mean velocity* in circular sewers

and conduits is the same when running half full as when running full.

Application and Use of the Tables.

To find the mean velocity in feet per second and the discharge in cubic feet per second.

Example 1.—A circular brick sewer has a diameter of 3 feet and a fall of 1 in 500. What is its mean velocity in feet per second and also its discharge in cubic feet per second?

By formula (1) $v = c\sqrt{r} \times \sqrt{s}.$

In column 4 of table 1 and opposite 3 feet diameter the value $c\sqrt{r}$ is found equal to 80.77, and in table 2 opposite 1 in 500 the value of $\sqrt{s}$ is found equal to .044721; substituting these values in equation, we have:

$v = 80.77 \times .044721$

$= 3.61$ feet per second the mean velocity.

By formula (5) $Q = av = a \times 3.61$, but by table 2 the area of a sewer 3 feet in diameter $= 7.068$; substitute this value in equation and

$$Q = 7.068 \times 3.61$$
$= 25.52$, the discharge in cubic feet per second.

Again, as a check,

By formula (5) $Q = ac\sqrt{r} \times \sqrt{s}$.

In column 4 of table 1, and opposite 3 feet diameter the value of $ac\sqrt{r}$ is given as 570.9, substituting this value and also the value of $\sqrt{s}$, as found above, in equation we have

$$Q = 570.9 \times .044721 = 25.53$$

cubic feet per second the discharge, which is the same as already found above.

Example 2.—*To find the diameter.*—(d). The grade (s) of a sewer is to be 1 in 480, and its mean velocity (v) 4 feet per second. What is the required diameter? By formula (2),

$$c\sqrt{r} = \frac{v}{\sqrt{s}}$$

In column 3 of table 2 we find for a slope of 1 in 480 that $\sqrt{s}$ is equal to .045644. Substitute this in equation, and also the value of v already given, and

$$c\sqrt{r} = \frac{4}{.045644} = 87.63.$$

Now look in column 4 of table 1 for the nearest value of $c\sqrt{r}$ to this which we find to be 87.15, opposite 3 feet 4 inches in diameter, which is the diameter required.

Example 3.—*To find the grade of Sewer.*—A sewer 2 feet 6 inches diameter is to have a velocity when running full or half full of not more than $3\frac{1}{2}$ feet a second. What should its grade be?

By formula (3) $\sqrt{s} = \dfrac{v}{c\sqrt{r}}$.

In column 4 of table 1 find opposite the diameter 2 feet 6 inches that $c\sqrt{r}$ is equal to 70.74. Substitute this value and also the value of v already given in equation, and $\sqrt{s} = \dfrac{3.5}{70.74} = .049477$. Now look out the nearest the value of $\sqrt{s}$ to this in column 3 of table 2, which we find to be .049507, opposite a slope of 1 in 408, which is the required grade.

To find the grade of sewer when the grade is not given in Table 2.

Example 4.—A sewer having a diameter of 8 feet is to have a velocity of

$3\frac{1}{2}$ feet per second. What is its required grade?

By formula (3) $\sqrt{s}=\frac{v}{c\sqrt{r}}$. Look out the value of $c\sqrt{r}$ for 8 feet diameter in Table 1, and it will be found to be 158.7. Substitute this value and also the value of v already given in equation, and

$$\sqrt{s}=\frac{3.5}{158.7}=.022054.$$

On looking for this value of $\sqrt{s}$ in Table 2 it is not to be found, therefore square each side of equation

$$\sqrt{s}=.022054 \text{ and we get}$$
$$s=.000486379$$

and $\frac{1}{.000486379}=2056$, therefore the slope is 1 in 2056.

To find the diameter (d).

Example 5.—A sewer is to discharge 9 cubic per second and its grade is to be 1 in 200. What is its diameter to be?

By formula (7) $ac\sqrt{r}=\frac{Q}{\sqrt{s}}$. In the third column of Table 2 and opposite 1 in 200 the value of $\sqrt{s}$ is found to be .070710. Substitute this value and the discharge already given in equation, and we have $ac\sqrt{r}=\frac{9}{.070710}=127.28$. In column 5 of Table 1, the value of $ac\sqrt{r}$ nearest to this we find to be 130.58, opposite to which is the diameter of 1 foot 9 inches, which is the diameter required.

To find the grade or slope of sewer. (s).

Example 6.—A sewer 6 feet in diameter is required to discharge 180 cubic feet of water per second. What should be its slope?

By formula (8) $\sqrt{s}=\frac{Q}{ac\sqrt{r}}$. In column 5 of Table 1 and opposite 6 feet in diameter the valve of $ac\sqrt{r}$ is found equal to 3702.3. Substitute this and also the value of Q in equation, and we have

$\sqrt{s}=\frac{180}{3702.3}=.048618$. Now in

column 4 of Table 2 look out the number nearest to this, which will be found to be .048621 opposite a slope 1 in 423, therefore the required grade is 1 in 423.

To find diameters in a series of sewers with increasing discharge.

Example 7.—A circular sewer has for 500 feet in length to discharge 10 cubic feet per second, then for 600 feet more has to discharge 12 cubic feet feet per second, and again for 700 feet, farther on 15 cubic feet per second. The total fall available is 5 feet. What is the required diameter and fall of each section? The total length is 1800 feet and $\frac{5}{1800} = .002777 = s$ and $\sqrt{.002777} = .052705 = \sqrt{s}$.

By formula (7) $ac\sqrt{r} = \frac{Q}{\sqrt{s}}$.

In this equation substitute values of Q and s for each section and find the corresponding diameters, which will be the diameters required.

$$\left.\begin{array}{l} ac\sqrt{r}=\dfrac{10}{.052705}=189.7 \\ ac\sqrt{r}=\dfrac{12}{.052705}=227.7 \\ ac\sqrt{r}=\dfrac{15}{.052705}=284.6 \end{array}\right\}\begin{array}{c}\text{Opposite which in}\\\text{Table 1 is}\end{array}\left\{\begin{array}{l} \text{diam.} 2'-0'' \\ \text{diam.} 2'-2'' \\ \text{diam.} 2'-4'' \end{array}\right.$$

Now $s=\frac{h}{l}$ $\therefore$ $h=sl$, therefore the

Fall of first section $=sl=.002777$
$\times 500$ .... $=1.39$ ft.
Fall of second section $=sl=.002777$
$\times 600$ .... $=1.67$ "
Fall of third section $=sl=.002777$
$\times 700$ .... $=1.95$ "

Total fall .... 5.00 ft.

We have, therefore,

1st	section, diameter	$2'-0''$,	fall	1.39 ft.
2d	" "	$2'-2''$	"	1.67 "
3d	" "	$2'-4''$	"	1.94 "

To find velocity and discharge of trapezoidal channel.

Example 8.—A trapezoidal channel lined with brickwork, 6 feet wide at bottom and with side slopes of 1 to 1, has 2

feet in depth of water and a grade of 1 in 160. What is its velocity and discharge per second?

$$\text{Area } (a)=\frac{6+10}{2}\times 2=16 \text{ square feet.}$$

Wetted perimeter $(p) = 2 \times \sqrt{2^2 \times 2^2} + 6 = 11.66$ feet.

∴ Hydraulic mean depth

$$(r)=\frac{a}{p}=\frac{16}{11.66}=1.372.$$

In column 3 of Table 1 look out the nearest value of r to this which we find to be 1.375, and corresponding to this we find $c\sqrt{r}$ equal to 123.5. In Table 2 for a slope of 1 in 160 the value of $\sqrt{s}$ is found to be $=.079057$.

Now by formula (1) $v=c\sqrt{r}\times\sqrt{s}$ and
" " " (5) $Q=av$ substituting the values above found of the factors, then $v = 123.5 \times 079057 = 9.76$ feet per second and $Q=16\times 9.76=156.2$ cubic feet per second, therefore the mean velocity is equal to 9.76 feet per second and the discharge equal to 156.2 cubic feet per second.

To find the dimensions of a circular sewer to replace a rectangular brick channel.

Example 9.—An open brick channel 5 feet wide at bottom, with vertical sides, has a depth of water in floods of 3 feet and a slope of 1 in 520. It is intended to substitute for it a circular sewer whose mean velocity flowing full shall be about 5 ft. per second. What should be the diameter and grade of the new circular sewer flowing full?

In Table 2 the $\sqrt{s}$ for a grade of 1 in $520 = .043853$.

Area of rectangular channel $(a) = 5 \times 3 = 15$ sq. ft. Wetted perimeter $(p) = 3 + 5 + 3 = 11$ feet. $\therefore$ Hydraulic mean depth $(r) = \frac{a}{p} = \frac{15}{11} = 1.364$. In Table 1 find corresponding to this hydraulic mean depth the nearest $c\sqrt{r}$, which is 123.5.

By formula (5) $Q = a \times c\sqrt{r} \times \sqrt{s}$ substitute the values found above, of the factors in right hand side of equation, and $Q = 15 \times 123.5 \times .043853 = 81.24$ cubic feet

per second, the discharge from the rectangular channel.

We have now to find the diameter and grade of a circular sewer to convey this quantity of water with a velocity not greater than 5 feet per second.

By formula (6) $a=\frac{Q}{v}$ substitute values

$a=\frac{81.26}{5}=16.252$ square feet=area of circular sewer. In column 2 of Table 1 we find the area nearest in value to this $=16.499$, and the corresponding diameter equal to 4 feet 7 inches, and at the same time find the value of the corresponding $ac\sqrt{r}$ which is 1796.5.

By formula (8) $\sqrt{s}=\frac{Q}{ac\sqrt{r}}$ substitute values of Q and $ac\sqrt{r}$ found above and

$$\sqrt{s}=\frac{81.26}{1796.5}=045232.$$

In Table 2 we find the grade corresonding to this equal to 1 in 489, therefore the diameter of circular sewer is 4 feet 7 inches, and the grade 1 in 489.

CIRCULAR SEWERS AND CONDUITS FLOWING FULL.

TABLE I.—GIVING VALUES OF a AND r AND ALSO THE FACTORS $c\sqrt{r}$ AND ALSO $ac\sqrt{r}$.

These factors are to be used only where the value of n, that is the coefficient of roughness of lining of channel=.015, as in second class or rough-faced brickwork, well-dressed stone work, foul and slightly tuberculated iron, cement and terra cotta pipes with imperfect joints and in bad order.

$$v=c\sqrt{r}\times\sqrt{s}. \quad Q=av=ac\sqrt{r}\times\sqrt{s}.$$

d = diameter in ft. in.	a = area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge. $ac\sqrt{r}$
0 5	0.136	0.104	17.36	2.3615
0 6	0.196	0.125	20.21	3.9604
0 7	0.267	0.146	22.95	6.1268
0 8	0.349	0.167	25.56	8.9194

d = diameter in ft. in.		a = area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
0	9	0.442	0.187	28.10	12.421
0	10	0.545	0.208	30.52	16.633
0	11	0.660	0.229	33.03	21.798
1	0	0.785	0.250	35.40	27.803
1	1	0.922	0.271	37.60	34 664
1	2	1 069	0.292	39.85	42.602
1	3	1.227	0.312	42.05	51.600
1	4	1.396	0.333	44.19	61.685
1	5	1.576	0.354	46.36	73.066
1	6	1.767	0.375	48.38	85.496
1	7	1.969	0.396	50.40	99.242
1	8	2.182	0.417	52.45	114.46
1	9	2.405	0.437	54.29	130.58

d=diameter in ft. in.	a=area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
1 10	2.640	0.458	56.29	148.61
1 11	2.885	0.479	58.20	167.90
2 0	3.142	0.500	60.08	188.77
2 1	3.409	0.521	61.95	211.20
2 2	3.687	0.542	63.72	234.94
2 3	3.976	0.562	65.51	260.47
2 4	4.276	0.583	67.32	287.87
2 5	4.587	0.604	69.02	316.59
2 6	4.909	0.625	70.74	347.28
2 7	5.241	0.646	72.59	380.46
2 8	5.585	0.667	74.27	414.81
2 9	5.939	0.687	75.98	451.23
2 10	6.305	0.708	77.56	488.99

d = diameter in ft. in.		a = area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
2	11	6.681	0.729	79.16	528.85
3	0	7.068	0.750	80.77	570.90
3	1	7.466	0.771	82.39	615.14
3	2	7.875	0.792	84.03	661.77
3	3	8.295	0.812	85.54	709.56
3	4	8.726	0.833	87.15	760.44
3	5	9.169	0.854	88.61	812.38
3	6	9.621	0.875	90.11	866.91
3	7	10.084	0.896	91.60	923.70
3	8	10.559	0.917	93.11	983.11
3	9	11.044	0.937	94.62	1045.0
3	10	11.541	0.958	96.15	1109.6
3	11	12.048	0.979	97.55	1175.2

d=diameter in ft.	in.	a = area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
4	0	12.566	1.000	99.10	1245.3
4	1	13.096	1.021	100.5	1315.8
4	2	13.635	1.042	102.0	1390.8
4	3	14.186	1.062	103.4	1466.7
4	4	14.748	1.083	104.8	1545.7
4	5	15.321	1.104	106.2	1627.0
4	6	15.904	1.125	107.6	1711.4
4	7	16.499	1.146	108.9	1796.5
4	8	17.104	1.167	110.3	1886.8
4	9	17.721	1.187	111.6	1977.7
4	10	18.348	1.208	113.0	2074.1
4	11	18.986	1.229	114.4	2172.9
5	0	19.635	1.250	115.7	2272.7

d=diameter in ft. in.	a=area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
5 1	20.295	1.271	117.1	2376.7
5 2	20.966	1.292	118.4	2482.0
5 3	21.648	1.312	119.7	2590.5
5 4	22.340	1.333	121.0	2702.1
5 5	23.044	1.354	122.2	2816.7
5 6	23.758	1.375	123.5	2934.8
5 7	24.484	1.396	124.8	3056.4
5 8	25.220	1.417	126.0	3177.3
5 9	25.967	1.437	127.3	3305.6
5 10	26.725	1.558	128.6	3436.3
5 11	27.494	1.479	129.7	3566.6
6 0	28.274	1.500	131.0	3702.3
6 3	30.680	1.562	134.6	4130.3

d = diameter in ft.	in.	a = area in square ft.	r = hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
6	6	33.183	1.625	138.3	4588.3
6	9	35.785	1.687	141.8	5074.7
7	0	38.485	1.750	145.3	5591.6
7	3	41.283	1.812	148.7	6136.8
7	6	44.179	1.875	152.0	6717.0
7	9	47.173	1.937	155.5	7333.5
8	0	50.266	2.000	158.7	7978.3
8	3	53.456	2.062	162.0	8658.8
8	6	56.745	2.125	165.3	9377.9
8	9	60.132	2.187	168.4	10128
9	0	63.617	2.250	171.6	10917
9	3	67.201	2.312	174.7	11740
9	6	70.882	2.375	177.7	12594

d = diameter in ft.	in.	a=area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
9	9	74.662	2.437	180.7	13489
10	0	78.540	2.500	183.7	14426
10	3	82.516	2.562	186.7	15406
10	6	86.590	2.625	189.5	16412
10	9	90.763	2.687	192.4	17462
11	0	95.033	2.750	195.2	18555
11	3	99.402	2.812	198.1	19694
11	6	103.87	2.875	201.0	20879
11	9	108.43	2.937	203.7	22093
12	0	113.10	3.000	206.5	23352
12	3	117.86	3.062	209.2	24658
12	6	122.72	3.125	212.0	26012
12	9	127.68	3.187	214.6	27399
13	0	132.73	3.250	217.4	28850

d=diameter in ft.	in.	a = area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $a^c\sqrt{r}$
13	3	137.88	3.312	220.0	30330
13	6	143.14	3.375	222.6	31860
13	9	148.49	3.437	225.2	33441
14	0	153.94	3.500	227.8	35073
14	3	159.48	3.562	230.0	36736
14	6	165.13	3.625	232.9	38454
14	9	170.87	3.687	235.4	40221
15	0	176.72	3.750	237.9	42040
15	3	182.65	3.812	240.5	43931
15	6	188.69	3.875	242.8	45820
15	9	194.83	3.937	245.3	47792
16	0	201.06	4.000	247.8	49823
16	3	207.40	4.062	250.3	51904
16	6	213.83	4.125	252.7	54056

d=diameter in ft.	in.	a = area in square ft.	r=hydraulic mean depth.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
16	9	220.35	4.187	254.9	56171
17	0	226.98	4.250	257.2	58387
17	3	233.71	4.312	259.7	60700
17	6	240.53	4.375	261.9	62999
17	9	247.45	4.437	264.4	65428
18	0	254.47	4.500	266.6	67839
18	3	261.59	4.562	268.9	70346
18	6	268.80	4.625	271.3	72916
18	9	276.12	4.687	273.5	75507
19	0	283.53	4.750	275.8	78201
19	3	291.04	4.812	278.0	80216
19	6	298.65	4.875	280.2	83686
19	9	306.36	4.937	282.4	86526
20	0	314.16	5.000	284.6	89423

TABLE 2.

GIVING VALUES OF s AND $\sqrt{s}$.

s = sine of slope = fall of water surface (h) in any distance (l), divided by that distance $= \frac{h}{l}$.

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
4	.250000000	.500000
5	.200000000	.447214
6	.166666660	.408248
7	.142857143	.377978
8	.125000000	.353553
9	.111111111	.333333
10	.100000000	.316228
11	.090909090	.301511
12	.083333333	.288675

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
13	.076923077	.277350
14	.071428571	.267261
15	.066666667	.258199
16	.062500000	.250000
17	.058823529	.242536
18	.055555555	.235702
19	.052631579	.229416
20	.050000000	.223607
21	.047619048	.218218
22	.045454545	.213200
23	.043478261	.208514
24	.041666667	.204124
25	.040000000	.200000
26	.038461538	.196116

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
27	.037037037	.192450
28	.035714286	.188982
29	.034452759	.185695
30	.033333333	.182574
31	.032258065	.179605
32	.031250000	.176777
33	.030303030	.174077
34	.029411765	.171499
35	.028571429	.169031
36	.027777778	.166667
37	.027027027	.164399
38	.026315789	.162221
39	.025641026	.160125
40	.025000000	.158114

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
41	.024390244	.156174
42	.023809524	.154303
43	.023255814	.152499
44	.022727273	.150756
45	.022222222	.149071
46	.021739130	.147444
47	.021276600	.145865
48	.020833333	.144337
49	.020408163	.142857
50	.020000000	.141421
51	.019607843	.140028
52	.019230769	.138676
53	.018867925	.137361
54	.018518519	.136085

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
55	.018181818	.134839
56	.017850143	.133630
57	.017543860	.132453
58	.017241379	.131305
59	.016949153	.130189
60	.016666667	.129100
61	.016393443	.128037
62	.016129032	.127000
63	.015873016	.125988
64	.015625000	.125000
65	.015384615	.124035
66	.015151515	.123091
67	.014925353	.122169
68	.014705882	.121286

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
69	.014492754	.120386
70	.014285714	.119524
71	.014084507	.118678
72	.013888889	.117851
73	.013698630	.117041
74	.013513514	.116248
75	.013333333	.115470
76	.013157895	.114708
77	.012987013	.113961
78	.012820513	.113228
79	.012658228	.112509
80	.012500000	.111803
81	.012345679	.111111
82	.012195122	.110431

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
83	.012048193	.109764
84	.011904762	.109109
85	.011764706	.108465
86	.011627907	.107833
87	.011494253	.107211
88	.011363636	.106600
89	.011235955	.106000
90	.011111111	.105409
91	.010989011	.104828
92	.010869565	.104257
93	.010752688	.103695
94	.010638298	.103142
95	.010526316	.102598
96	.010416667	.102062

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
97	.010309278	.101535
98	.010204082	.101015
99	.010101010	.100504
100	.010000000	.100000
101	.009900990	.099504
102	.009803922	.099015
103	.009708738	.098533
104	.009615385	.098058
105	.009523810	.097590
106	.009433962	.097129
107	.009345794	.096674
108	.009259259	.096225
109	.009174312	.095783
110	.009090909	.095346

Slope 1 in	s=sine of slope.	$\sqrt{s}$
111	.009009009	.094916
112	.008928571	.094491
113	.008849558	.094072
114	.008771930	.093659
115	.008695652	.093250
116	.008620690	.092848
117	.008547009	.092450
118	.008474576	.092057
119	.008403361	.091669
120	.008333333	.091287
121	.008264463	.090909
122	.008196721	.090536
123	.008130081	.090167
124	.008064516	.089803

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
125	.008000000	.089442
126	.007836508	.089087
127	.007874016	.088736
128	.007812500	.088388
129	.007751938	.088045
130	.007692308	.087706
131	.007633588	.087370
132	.007575758	.087039
133	.007518797	.086711
134	.007462687	.086387
135	.007407407	.086066
136	.007352941	.085749
137	.007299270	.085436
138	.007246377	.085126

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
139	.007194245	.084819
140	.007142857	.084516
141	.007092199	.084215
142	.007042254	.083918
143	.006993007	.083624
144	.006944444	.083333
145	.006896552	.083046
146	.006849315	.082760
147	.006802721	.082479
148	.006756757	.082199
149	.006711409	.081923
150	.006666667	.081650
151	.006622517	.081379
152	.006578947	.081111

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
153	.006535948	.080845
154	.006493506	.080582
155	.006451613	.080322
156	.006410256	.080065
157	.006369427	.079809
158	.006329114	.079556
159	.006289308	.079305
160	.006250000	.079057
161	.006211180	.078811
162	.006172840	.078568
163	.006134969	.078326
164	.006097561	.078087
165	.006060606	.077850
166	.006024096	.077615

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
167	.005988024	.077382
168	.005952381	.077152
169	.005917160	.076923
170	.005882353	.076697
171	.005847953	.076472
172	.005813953	.076249
173	.005780347	.076029
174	.005747126	.075810
175	.005714286	.075593
176	.005681818	.075378
177	.005649718	.075164
178	.005617978	.074953
179	.005586592	.074744
180	.005555556	.074536

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
181	.005524862	.074329
182	.005494505	.074125
183	.005464481	.073922
184	.005434783	.073721
185	.005405405	.073521
186	.005376344	.073324
187	.005347594	.073127
188	.005319149	.072932
189	.005291005	.072739
190	.005263158	.072548
191	.005235602	.072357
192	.005208333	.072169
193	.005181347	.071982
194	.005154639	.071796

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
195	.005128205	.071612
196	.005102041	.071429
197	.005076142	.071247
198	.005050505	.071067
199	.005025126	.070888
200	.005000000	.070710
201	.004975124	.070534
202	.004950495	.070359
203	.004926108	.070186
204	.004901961	.070014
205	.004878049	.069843
206	.004854369	.069673
207	.004830918	.069505
208	.004807692	.069338

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
209	.004784689	.069172
210	.004761905	.069007
211	.004739336	.068843
212	.004716981	.068680
213	.004694836	.068519
214	.004672897	.068358
215	.004651163	.068199
216	.004629630	.068041
217	.004608295	.067885
218	.004587156	.067729
219	.004566210	.067574
220	.004545455	.067419
221	.004524887	.067267
222	.004504505	.067116

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
223	.004484305	.066965
224	.004464286	.066815
225	.004444444	.066667
226	.004424779	.066519
227	.004405286	.066372
228	.004385965	.066227
229	.004366812	.066082
230	.004347826	.065938
231	.004329004	.065795
232	.004310345	.065653
233	.004291845	.065512
234	.004273504	.065372
235	.004255319	.065233
236	.004237288	.065094

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
237	.004219409	.064957
238	.004201681	.064820
239	.004184100	.064685
240	.004166667	.064549
241	.004149378	.064416
242	.004132231	.064283
243	.004115226	.064150
244	.004098361	.064018
245	.004081623	.063888
246	.004065041	.063758
247	.004048583	.063629
248	.004032258	.063500
249	.004016064	.063372
250	.004000000	.063246

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
251	.003984064	.063119
252	.003968254	.062994
253	.003952569	.062870
254	.003937008	.062746
255	.003921569	.062622
256	.003906250	.062500
257	.003891051	.062378
258	.003875969	.062257
259	.003861004	.062137
260	.003846154	.062018
261	.003831418	.061899
262	.003816794	.061780
263	.003802281	.061662
264	.003787879	.061546

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
265	.003773585	.061430
266	.003759398	.061314
267	.003745319	.061199
268	.003731343	.061085
269	.003717472	.060971
270	.003703704	.060858
271	.003690037	.060746
272	.003676471	.060634
273	.003663004	.060523
274	.003649635	.060412
275	.003636364	.060302
276	.003623188	.060193
277	.003610108	.060084
278	.003597122	.059976

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
279	.003584229	.059868
280	.003571429	.059761
281	.003558719	.059655
282	.008546099	.059549
283	.003533569	.059444
284	.003521127	.059339
285	.003508772	.059235
286	.003496503	.059131
287	.003484321	.059028
288	.003472222	.058926
289	.003460208	.058824
290	.003448276	.058722
291	.003436426	.058621
292	.003424658	.058520

Slope 1 in	s=side of slope.	$\sqrt{s}$.
293	.003412969	.058420
294	.003401361	.058321
295	.003389831	.058222
296	.003378378	.058124
297	.003367003	.058026
298	.003355705	.057929
299	.003344482	.057831
300	.003333333	.057735
301	.003322259	.057639
302	.003311258	.057544
303	.003300330	.057449
304	.003289474	.057354
305	.003278689	.057260
306	.003267974	.057166

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
307	.003257329	.057073
308	.003246753	.056980
309	.003236246	.056888
310	.003225806	.056796
311	.003215434	.056705
312	.003205128	.056614
313	.003194888	.056523
314	.003184713	.056433
315	.003174603	.056344
316	.003164557	.056254
317	.003154574	.056165
318	.003144654	.056077
319	.003134796	.055989
320	.003125000	.055902

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
321	.003115265	.055815
322	.003105590	.055728
323	.003095975	.055641
324	.003086420	.055556
325	.003076923	.055470
326	.003067485	.055385
327	.003058104	.055300
328	.003048780	.055216
329	.003039514	.055132
330	.003030303	.055048
331	.003021148	.054965
332	.003012048	.054882
333	.003003003	.054799
334	.002994012	.054717

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
335	.002985075	.054636
336	.002976190	.054555
337	.002967359	.054474
338	.002958580	.054393
339	.002949853	.054312
340	.002941176	.054232
341	.002932551	.054153
342	.002923977	.054074
343	.002915452	.053995
344	.002906977	.053916
345	.002898551	.053838
346	.002890171	.053760
347	.002881844	.053683
348	.002873563	.053606

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
349	.002865330	.053529
350	.002857143	.053452
351	.002849003	.053376
352	.002840909	.053300
353	.002832861	.053224
354	.002824859	.053149
355	.002816901	.053074
356	.002808989	.052999
357	.002801120	.052925
358	.002793296	.052851
359	.002785515	.052778
360	.002777778	.052705
361	.002770083	.052632
362	.002762431	.052559

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
363	.002754821	.052486
364	.002747253	.052414
365	.002739726	.052342
366	.002732240	.052270
367	.002724796	.052199
368	.002717391	.052129
369	.002710027	.052060
370	.002702703	.051988
371	.002695418	.051917
372	.002688172	.051847
373	.002680965	.051778
374	.002673797	.051709
375	.002666667	.051640
376	.002659574	.051571

Slope 1 in	s=sine of slope.	$\sqrt{s}$
377	.002652520	.051502
378	.002645503	.051434
379	.002638522	.051366
380	.002631579	.051299
381	.002624672	.051231
382	.002617801	.051164
383	.002610966	.051097
384	.002604167	.051031
385	.002597403	.050965
386	.002590674	.050899
387	.002583979	.050833
388	.002577320	.050767
389	.002570694	.050702
390	.002564103	.050637

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
391	.002557545	.050572
392	.002551020	.050507
393	.002544529	.050443
394	.002538071	.050379
395	.002531646	.050315
396	.002525253	.050252
397	.002518892	.050188
398	.002512563	.050125
399	.002506266	.050062
400	.002500000	.050000
401	.002493766	.049938
402	.002487562	.049876
403	002481390	.049814
404	.002475248	.049752

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
405	.002469136	.049690
406	.002463054	.049629
407	.002457002	.049568
408	.002450980	.049507
409	.002444988	.049447
410	.002439024	.049387
411	.002433090	.049326
412	.002427184	.049266
413	.002421308	.049207
414	.002415459	.049147
415	.002409639	.049088
416	.002403846	.049029
417	.002398082	.048970
418	.002392344	.048911

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
419	.002386635	.048853
420	.002380952	.048795
421	.002375297	.048737
422	.002369668	.048679
423	.002364066	.048621
424	.002358491	.048564
425	.002352941	.048507
426	.002347418	.048450
427	.002341920	.048393
428	.002336449	.048337
429	.002331002	.048280
430	.002325581	.048224
431	.002320186	.048168
432	.002314815	.048113

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
433	.002309469	.048057
434	.002304147	.048001
435	.002298851	.047946
436	.002293578	.047891
437	.002288330	.047836
438	.002283105	.047782
439	.002277904	.047728
440	.002272727	.047673
441	.002267574	.047619
442	.002262443	.047565
443	.002257336	.047511
444	.002252252	.047458
445	.002247191	.047404
446	.002242152	.047351

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
447	.002237136	.047298
448	.002232143	.047245
449	.002227194	.047193
450	.002222222	.047140
451	.002217295	.047088
452	.002212389	.047036
453	.002207506	.046984
454	.002202643	.046932
455	.002197802	.046880
456	.002192982	.046829
457	.002188184	.046778
458	.002183406	.046726
459	.002178649	.046676
460	.002173913	.046625

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
461	.002169197	.046575
462	.002164502	.046524
463	.002159827	.046474
464	.002155172	.046424
465	.002150538	.046374
466	.002145923	.046324
467	.002141328	.046274
468	.001136752	.046225
469	.002132196	.046176
470	.002127660	.046126
471	.002123142	.046077
472	.002118644	.046029
473	.002114165	.045980
474	.002109705	.045932

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
475	.002105263	.045883
476	.002100840	.045835
477	.002096436	.045787
478	.002092050	.045739
479	.002087683	.045691
480	.002083333	.045644
481	.002079002	.045596
482	.002074689	.045549
483	.002070393	.045502
484	.002066116	.045454
485	.002061856	.045407
486	.092057613	.045361
487	.002053388	.045314
488	.002049180	.045268

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
489	.002044990	.045222
490	.002040816	.045175
491	.002036660	.045129
492	.002032520	.045085
493	.002028398	.045037
494	.002024291	.044992
495	.002020202	.044947
496	.002016128	.044901
497	.002012072	.044856
498	.002008032	.044811
499	.002004008	.044766
500	.002000000	.044721
501	.001996008	.044677
502	.001992032	.044632

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
503	.001988072	.044588
504	.001984127	.044544
505	.001980198	.044499
506	.001976285	.044455
507	.001972387	.044412
508	.001968504	.044368
509	.001964637	.044324
510	.001960784	.044281
511	.001956947	.044237
512	.001953125	.044194
513	.001949318	.044151
514	.001945525	.044108
515	.001941748	.044065
516	.001937984	.044022

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
517	.001944246	.043979
518	.008930502	.043937
519	.001926782	.043895
520	.001923077	.043853
521	.001919386	.043811
522	.001915709	.043769
523	.001912046	.043727
524	.001908397	.043685
525	.001904762	.043644
526	.001901141	.043602
527	.001897533	.043561
528	.001893939	.043519
529	.001890359	.043478
530	.001886792	.043437

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
531	.001883239	.043396
532	.001879699	.043355
533	.001876173	.044315
534	.001872659	.043274
535	.001869159	.043234
536	.001865672	.043193
537	.001862197	.043153
538	.001858736	.043113
539	.001855288	.043073
540	.001851852	.043033
541	.001848429	.042993
542	.001845018	.042953
543	.001841621	.042914
544	.001838235	.042874

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
545	.001834862	.042835
546	.001831502	.042796
547	.001828154	.042757
548	.001824817	.042718
549	.001821494	.042679
550	.001818182	.042640
551	.001814882	.042601
552	.001811594	.042563
553	.001808318	.042524
554	.001805054	.042486
555	.001801802	.042448
556	.001798561	.042410
557	.001795332	.042371
558	.001792115	.042333

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
559	.001788909	.042295
560	.001785714	.042258
561	.001782531	.042220
562	.001779359	.042183
563	.001776199	.042145
564	.001773050	.042108
565	.001769912	.042070
566	.001766784	.042033
567	.001763668	.041996
568	.001760563	.041959
569	.001757469	.041922
570	.001754386	.041885
571	.001751313	.041848
572	.001748252	.041812

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
573	.001745201	.041776
574	.001742160	.041739
575	.001739130	.041703
576	.001736111	.041667
577	.001733102	.041630
578	.001730104	.041594
579	.001727116	.041559
580	.001724138	.041523
581	.001721170	.041487
582	.001718213	.041451
583	.001715266	.041416
584	.001712329	.041380
585	.001709420	.041345
586	.001706485	.041309

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
587	.001703578	.041274
588	.001700680	.041239
589	.001697793	.041204
590	.001694915	.041169
591	.001692047	.041135
592	.001689189	.041100
593	.001686341	.041065
594	.001683502	.041031
595	.001680672	.040996
596	.001677852	.040961
597	.001675042	.040927
598	.001672241	.040893
599	.001669449	.040859
600	.001666667	.040825

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
601	.001663894	.040791
602	.001661130	.040757
603	.001658375	.040723
604	.001655629	.040689
605	.001652893	.040656
606	.001650165	.040622
607	.001647446	.040589
608	.001644737	.040555
609	.001642036	.040522
610	.001639344	.040489
611	.001636661	.040456
612	.001633987	.040422
613	.001631321	.040389
614	.001628664	.040357

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
615	.001626016	.040324
616	.001623377	.040291
617	.001620746	.040258
618	.001618123	.040226
619	.001615509	.040193
620	.001612903	.040161
621	.001610306	.040128
622	.001607717	.040096
623	.001605136	.040064
624	.001602564	.040032
625	.001600000	.040000
626	.001597444	.039968
627	.001594896	.039936
628	.001592357	.039904

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
629	.001589825	.039873
630	.001587302	.039841
631	.001584786	.039809
632	.001582278	.039778
633	.001579779	.039746
634	.001577287	.039715
635	.001574803	.039684
636	.001572327	.039653
637	.001569859	.039621
638	.001567398	.039590
639	.001564945	.039559
640	.001562500	.039528
641	.001560062	.039498
642	001557632	.039467

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
643	.001555210	.039436
644	.001552795	039405
645	.001550388	.039375
646	.001547988	.039344
647	.001545595	.039314
648	.001543210	.039284
649	.001540832	.039253
650	.001538462	.039223
651	.001536098	.039193
652	.001533742	.039163
653	.001531394	.038133
654	.001529052	.039103
655	.001526718	.039073
656	.001524390	.039043

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
657	.001522070	.039013
658	.001519757	.038984
659	.001517451	.038954
660	.001515152	.038925
661	.001512859	.038895
662	.001510574	.038866
663	.001508296	.038837
664	.001506024	.038808
665	.001503759	.038778
666	.001501502	.038749
667	.001499250	.038720
668	.001497006	.038691
669	.001494768	.038662
670	.001492537	.038633

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
671	.001490313	.038604
672	.001488095	.038576
673	.001485884	.038547
674	.001483680	.038518
675	.001481481	.038490
676	.001479290	.038461
677	.001477105	.038433
678	.001474926	.038405
679	.001472754	.038376
680	.001470588	.038348
681	.001468429	.038320
682	.001466276	.038292
683	.001464129	.038264
684	.001461988	.038236

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
685	.001459854	.038208
686	.001457726	.038180
687	.001455604	.038152
688	.001453488	.038125
689	.001451379	.038097
690	.001449275	.038069
691	.001447178	.038042
692	.001445087	.038014
693	.001443001	.037987
694	.001440922	.037959
695	.001438849	.037932
696	.001436782	.037905
697	.001434720	.037878
698	.001432665	.037851

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
699	.001430615	.037824
700	.001428571	.037796
701	.001426534	.037769
702	.001424501	.037743
703	.001422475	.037716
704	.001420455	.037689
705	.001418440	.037662
706	.001416431	.037636
707	.001414427	.037609
708	.001412429	.037582
709	.001410437	.037556
710	.001408451	.037529
711	.001406470	.037503
712	.001404494	.037477

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
713	.001402525	.037450
714	.001400560	.037424
715	.001398601	.037398
716	.001396648	.037372
717	.001394700	.037346
718	.001392758	.037320
719	.001390821	.037294
720	.001388889	.037268
721	.001386963	.037242
722	.001385042	.037216
723	.001383126	.037190
724	.001381215	.037164
725	.001379310	.037139
726	.001377410	.037113

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
727	.001375516	.037088
728	.001373626	.037063
729	.001371742	.037037
730	.001369863	.037012
731	.001367989	.036986
732	.001366120	.036961
733	.001364256	.036936
734	.001362398	.036911
735	.001360544	.036885
736	.001358696	.036860
737	.001356852	.036835
738	.001355014	.036810
739	.001353180	.036786
740	.001351351	.036761

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
741	.001349528	.036736
742	.001347709	.036711
743	.001345895	.036686
744	.001344086	.036662
745	.001342282	.036637
746	.001340483	.036613
747	.001338688	.036588
748	.001336898	.036563
749	.001335113	.036539
750	.001333333	.036515
751	.001331558	.036490
752	.001329787	.036466
753	.001328021	.036442
754	.001326260	.036418

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
755	.001324503	.036394
756	.001322751	.036370
757	.001321004	.036346
758	.001319261	.036322
759	.001317523	.036298
760	.001315789	.036274
761	.001314060	.036250
762	.001312336	.036226
763	.001310616	.036202
764	.001308901	.036179
765	.001307190	.036155
766	.001305483	.036131
767	.001303781	.036108
768	.001302083	.036084

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
769	.001300390	.036061
770	.001298701	.036038
771	.001297017	.036014
772	.001295337	.035991
773	.001293661	.035967
774	.001291990	.035944
775	.001290323	.035921
776	.001288660	.035898
777	.001287001	.035875
778	.001285347	.035852
779	.001283697	.035829
780	.001282051	.035806
781	.001280410	.035783
782	.001278772	.035760

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
783	.001277139	.035737
784	.001275510	.035714
785	.001273885	.035691
786	.001272265	.035669
787	.001270648	.035646
788	.001269036	.035623
789	.001267427	.035601
790	.001265823	.035578
791	.001264223	.035556
792	.001262626	.035533
793	.001261034	.035511
794	.001259446	.035489
795	.001257862	.035466
796	.001256281	.035444

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
797	.001254705	.035422
798	.001253133	.035399
799	.001251564	.035377
800	.001250000	.035355
801	.001248439	.035333
802	.001246883	.035311
803	.001245330	.035289
804	.001243781	.035267
805	.001242236	.035245
806	.001240695	.035223
807	.001239157	.035201
808	.001237624	.035179
809	.001236094	.035158
810	.001234568	.035136

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
811	.001233046	.035115
812	.001231527	.035093
813	.001230012	.035071
814	.001228501	.035050
815	.001226994	.035028
816	.001225490	.035007
817	.001223990	.034985
818	.001222494	.034964
819	.001221001	.034943
820	.001219512	.034922
821	.001218027	.034900
822	.001216545	.034879
823	.001215067	.034858
824	.001213592	.034837

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
825	.001212121	.034816
826	.001210654	.034794
827	.001290190	.034773
828	.001207729	.034752
829	.001206273	.034731
830	.001204819	.034710
831	.001203369	.034689
832	.001201923	.034669
833	.001200480	.034648
834	.001199041	.034627
835	.001197605	.034606
836	.001196172	.034586
837	.001194743	.034565
838	.001193317	.034544

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
839	.001191895	.034524
840	.001190476	.034503
841	.001189061	.034483
842	.001187648	.034462
843	.001186240	.034442
844	.001184834	.034421
845	.001183432	.034401
846	.001182033	.034381
847	.001180638	.034360
848	.001179245	.034340
849	.001177856	.034320
850	.001176471	.034300
851	.001175088	.034279
852	.001173709	.034259

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
853	.001172333	.034239
854	.001170960	.034219
855	.001169591	.034199
856	.001168224	.034179
857	.001166861	.034159
858	.001165501	.034139
859	.001164144	.034119
860	.001162791	.034099
861	.001161440	.034080
862	.001160093	.034060
863	.001158749	.034040
864	.001157407	.034021
865	.001156069	.034001
866	.001154734	.033981

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
867	.001153403	.033962
868	.001152074	.033942
869	.001150748	.033923
870	.001149425	.033903
871	.001148106	.033883
872	.001146789	.033864
873	.001145475	.033845
874	.001144165	.033825
875	.001142857	.033806
876	.001141553	.033787
877	.001140251	.033768
878	.001138952	.033748
879	.001137656	.033729
880	.001136364	.033710

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
881	.001135074	.033691
882	.001133787	.033672
883	.001132503	.033653
884	.001131222	.033633
885	.001129944	.033614
886	.001128668	.033595
887	.001127396	.033577
888	.001126126	.033558
889	.001124859	.033539
890	.001123596	.033520
891	.001122334	.033501
892	.001121076	.033483
893	.001119821	.033464
894	.001118568	.033445

Slope 1 in	s=sine of slope.	$\sqrt{s.}$
895	.001117318	.033426
896	.001116071	.033408
897	.001114827	.033389
898	.001113586	.033370
899	.001112347	.033352
900	.001111111	.033333
901	.001109878	.033315
902	.001108647	.033296
903	.001107420	.033278
904	.001106195	.033259
905	.001104972	.033241
906	.001103753	.033223
907	.001102536	.033204
908	.001101322	.033186

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
909	.001100110	.033168
910	.001098901	.033149
911	.001097695	.033131
912	.001096491	.033113
913	.001095290	.033095
914	.001094092	.033077
915	.001092896	.033059
916	.001091703	.033041
917	.001090513	.033023
918	.001089325	.033005
919	.001088139	.032987
920	.001086957	.032969
921	.001085776	.032951
922	.001084599	.032933

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
923	.001083423	.032915
924	.001082251	.032897
925	.001081081	.032879
926	.001079914	.032862
927	.001078749	.032844
928	.001077586	.032826
929	.001076426	.032809
930	.001075269	.032791
931	.001074114	.032774
932	.001072961	.032756
933	.001071811	.032738
934	.001070664	.032721
935	.001069519	.032703
936	.001068376	.032686

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
937	.001067236	.032669
938	.001066098	.032651
939	.001064963	.032634
940	.001063830	.032616
941	.001062699	.032599
942	.001061571	.032582
943	.001060445	.032565
944	.001059322	.032547
945	.001058201	.032530
946	.001057082	.032513
947	.001055966	.032496
948	.001054852	.032479
949	.001053741	.032461
950	.001052632	.032444

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
951	.001051525	.032427
952	.001050420	.032410
953	.001049318	.032393
954	.001048218	.032376
955	.001047120	.032359
956	.001046025	.032342
957	.001044932	.032325
958	.001043841	.032309
959	.001042753	.032292
960	.001041667	.032275
961	.001040583	.032258
962	.001039501	.032241
963	.001038422	.032224
964	.001037344	.032208

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
965	.001036269	.032191
966	.001035197	.032174
967	.001034126	.032158
968	.001033058	.032141
969	.001031992	.032125
970	.001030928	.032108
971	.001029866	.032091
972	.001028807	.032075
973	.001027749	.032059
974	.001026694	.032042
975	.001025641	.032026
976	.001024590	.032009
977	.001023541	.031993
978	.001022495	.031977

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
979	.001021450	.031960
980	.001020408	.031944
981	.001019368	.031928
982	.001018330	.031911
983	.001017294	.031895
984	.001016260	.031879
985	.001015228	.031863
986	.001014199	.031847
987	.001013171	.031830
988	.001012146	.031814
989	.001011122	.031798
990	.001010101	.031782
991	001009082	.031766
992	.001008065	.031750

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
993	.001007049	.031734
994	.001006036	.031718
995	.001005025	.031702
996	.001004016	.031686
997	.001003009	.031670
998	.001002004	.031654
999	.001001001	.031639
1000	.001000000	.031623
1010	.000990099	.031466
1020	.000980392	.031311
1030	.000970873	.031159
1040	.000961538	.031009
1050	.000952381	.030861
1060	.000943396	.030715

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
1070	.000934579	.030571
1080	.000925926	.030429
1090	.000917431	.030289
1100	.000909090	.030151
1110	.000900900	.030015
1120	.000892857	.029881
1130	.000884956	.029748
1140	.000877193	.029617
1150	.000869566	.029488
1160	.000862069	.029361
1170	.000854701	.029235
1180	.000847458	.029111
1190	.000840336	.028988
1200	.000833333	.028868

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
1220	.000819672	.028630
1240	.000806452	.028398
1260	.000793651	.028172
1280	.000781250	.027951
1300	.000769231	.027735
1320	.000757576	.027524
1340	.000746268	.027318
1360	.000735294	.027116
1380	.000724638	.026919
1400	.000714286	.026726
1420	.000704225	.026537
1440	.000694444	.026352
1460	.000684932	.026171
1480	.000675675	.025994

Slope 1 in	s=sine of slope.	$\sqrt{s}$.
1500	.000666666	.025820
1520	.000657895	.025649
1540	.000649351	.025482
1560	.000641025	.025318
1580	.000632911	.025158
1600	.000625000	.025000
1620	.000617284	.024845
1640	.000609756	.024693
1660	.000602409	.024744
1680	.000595238	.024398
1700	.000588235	.024254
1720	.000581395	.024112
1740	.000574712	.023973
1760	.000568182	.023836

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
1780	.000561798	.023702
1800	.000555555	.023570
1820	.000549450	.023440
1840	.000543478	.023313
1860	.000537634	.023187
1880	.000531915	.023063
1900	.000526316	.022942
1920	.000520833	.022822
1940	.000515464	.022704
1960	.000510204	.022588
1980	.000505050	.022473
2000	.000500000	.022361
2040	.000490196	.022140
2080	.000480769	.021927

Slope 1 in	s = sine of slope.	$\sqrt{s}$.
2120	.000471698	.021719
2160	.000462963	.021517
2200	.000454545	.021320
2240	.000446429	.021129
2280	.000438597	.020943
2320	.000431034	.020761
2360	.000423729	.020585
2400	.000416666	.020412
2440	.000409836	.020244
2480	.000403226	.020080
2520	.000396825	.019920
2560	.000390625	.019764
2600	.000384615	.019612
2640	.000378787	.019463

EGG-SHAPED SEWERS.

INTERNAL DIMENSIONS.

Hydraulic Tables Based on Kutter's Formula.

EGG-SHAPED SEWERS.—INTERNAL DIMENSIONS.

Depth of vertical diameter is 1.5 times the greatest transverse diameter; that is, the diameter of top of arch.

Let D = greatest transverse diameter, that is the diameter of top or arch $=\frac{2H}{3}$, then

H = depth of sewer or vertical diameter $=1.5D$.

B = radius of bottom or invert $=\frac{H}{6}$.

R = radius of sides = H.

By reference to column $c\sqrt{r}$ in Tables 3 and 4 it will be seen that the mean velocity of an egg-shaped sewer flowing two-thirds full is always *greater* than that of the mean velocity of same sewer flowing

full. When the slopes are equal, columns $c\sqrt{r}$ and $ac\sqrt{r}$ give a ready means for comparing velocities and discharges.

Application and Use of the Tables.

To find the velocity and discharge in an egg-shaped sewer.

Example 10.—An egg-shaped sewer 7 feet by 10 feet 6 inches has a slope of 6 feet per mile. What is its velocity and discharge flowing full, flowing two-thirds full depth and one-third full depth?

A slope of 6 feet per mile is equal to 1 in 880, opposite to which in Table 2 the value of $\sqrt{s}$ is found to be $= .03271$.

In Tables 3, 4 and 5 opposite a transverse diameter of 7 feet find the values of $c\sqrt{r}$ and $ac\sqrt{r}$ and substitute them and also the value of $\sqrt{s}$ above found in formula (1) $v=c\sqrt{r}\times\sqrt{s}$.

" (5) $Q=ac\sqrt{r}\times\sqrt{s}$ and we get the following:

Full depth. $\begin{cases} v=160.2 \times .03371=5.4 \text{ feet per second.} \\ Q=9015.7\times .03371 = 303.9 \text{ cubic feet per second.} \end{cases}$

Two-thirds depth. $\left\{ \begin{array}{l} v=169.6\times.03371=5.72 \text{ feet per second.} \\ Q=6283.5\times.03371=211.8 \text{ cubic feet per second.} \end{array}\right.$

One-third depth. $\left\{ \begin{array}{l} v=127.9\times.03371=4.31 \text{ feet per second.} \\ Q=1779.4\times.03371=59.98 \text{ cubic feet per second.} \end{array}\right.$

To find the dimensions of an egg-shaped sewer to replace a circular sewer.

Example 11.—A circular sewer 5 feet diameter and 4800 feet long has a fall of 16 feet. It is to be removed and replaced by an egg-shaped sewer with a fall of 8 feet whose discharge flowing full shall equal that of the circular sewer flowing full? Give dimensions of egg-shaped sewer.

A fall of 16 in 4800=1 in 300 and in Table 2 the $\sqrt{s}$ corresponding to this is .057735. In Table 1 opposite 5 feet diameter the value $ac\sqrt{r}$ is 2272.7, substitute this value and also the value of $\sqrt{s}$ in formula (5) $Q=ac\sqrt{r}\times\sqrt{s}$ and we have $Q=2272.7\times.057735=131.21$ cubic feet per second, the discharge of the circular

sewer. The egg-shaped sewer is to have a fall of 8 in 4800=1 in 600, and in Table 2 the equivalent $\sqrt{s}$ is 040825, substitute this value and also the discharge found above in

formula (7) $ac\sqrt{r}=\frac{Q}{\sqrt{s}}=\frac{131.21}{.040825}=$ 3213.9.

In Table 3, the nearest value of $ac\sqrt{r}$ to this is 3353 opposite a transverse diameter 4 feet 10 inches, therefore the egg-shaped sewer is to be 4 feet 10 inches by 7 feet 3 inches.

To find the diameter of a circular sewer whose discharge flowing full shall equal that of an egg-shaped sewer flowing one-third full depth.

Example 12.—Find the diameter of a circular sewer whose discharge flowing full shall equal that of the egg-shaped sewer in last example flowing one-third full the slope being the same in each.

In Table 5 and opposite transverse diameter 4 feet 10 inches the value of $ac\sqrt{r}$ =657.53.

In Table 1 the value of $ac\sqrt{r}$ nearest to this is found to be 661.77 opposite a diameter of 3 feet 2 inches, which is the diameter of the circular sewer required.

To find the diameter of a circular sewer whose velocity flowing full shall equal that of an egg-shaped sewer flowing one-third full depth.

Example 13.—What is the diameter of a circular sewer whose mean velocity flowing full shall equal that of an egg-shaped sewer 4 feet by 6 feet flowing one-third full, the grade in each being the the same?

In Table 5 and opposite the transverse diameter 4 feet the value of $c\sqrt{r}=86.61$.

In Table 1 the value of $c\sqrt{r}$ nearest to this is 87.15, opposite diameter 3 feet 4 inches, which is the diameter of the circular sewer required.

To find the dimensions and slope of an egg-shaped sewer flowing full, the mean velocity and discharge being given.

Example 14.—An egg-shaped sewer flowing full is to have a mean velocity not

greater than 5 feet per second, and is to discharge 108 cubic feet per second. What is size and slope?

By formula (6) $a = \frac{Q}{v}$ substitute values of Q and v given and $a = \frac{108}{5} = 21.6$ square feet.

In column 2 of Table 3 the nearest area to this is 21.556 opposite the transverse diameter 4 feet 4 inches, therefore the sewer required is 4 feet 4 inches by 6 feet 6 inches. At the same time the value of $ac\sqrt{r}$ opposite 4 feet 4 inches diameter is found equal to 2501.4, substitute this and also value of

formula (8) $\sqrt{s} = \frac{Q}{ac\sqrt{r}} = \frac{108}{2501.4} =$ .043176, and in Table 2 the nearest value of $\sqrt{s}$ to this is .043193 opposite the slope of 1 in 536, which is slope of sewer.

The diameter and slope of a circular sewer being given, to find dimensions and slope of an egg-shaped sewer whose discharge flowing two-thirds depth shall

equal that of the circular sewer flowing full and whose velocity at same depth shall not exceed a certain rate.

Example 15.—A circular sewer 6 feet in diameter and with a slope of 1 in 600 is to be removed and to be replaced by an egg-shaped sewer whose discharge flowing at two-thirds of its full depth shall be equal to that of the circular sewer flowing full and whose mean velocity at the same two-thirds depth shall not exceed 5 feet per second? Give dimensions and slope of egg-shaped sewer.

In Table 1 and opposite 6 feet diameter the value of $ac\sqrt{r}$ is 3702 3, and in Table 2 opposite 1 in 600 the value of $\sqrt{s}$ is .040825, substitute these values in formula (5) $Q=ac\sqrt{r} \times \sqrt{s}$ and we get

$Q=3702.3 \times .040825 = 151.15$ cubic feet per second, the discharge of the circular sewer. Now substitute this discharge and the velocity above given 5 feet per second in formula (6) $a=\frac{Q}{v}$ and we get $a=\frac{151.15}{5}=30.23$ square feet, the

area at two-thirds depth of the egg-shaped sewer. In column 2 of Table 4 the nearest area to this is 30.317 opposite a transverse diameter of 6 feet 4 inches, therefore the dimensions of egg-shaped sewer are 6 feet 4 inches by 9 feet 6 inches.

At the same time take out the value of $a\,c\sqrt{r}$ opposite 6 feet 4 inches, which is 4811.9. Substitute this and also the value of Q found in formula (8)

$$\sqrt{s} = \frac{Q}{ac\sqrt{r}} = .031412$$

and this not being found in Table 1, square each side and

$$s = .0009867,$$

and $\dfrac{1}{.0009867} = 1013$ nearly, therefore the slope of egg-shaped sewer is 1 in 1013 and its size 6 feet 4 inches by 9 feet 6 inches.

To find the dimensions and grade of an egg-shaped sewer to have a certain discharge flowing full, and whose mean velocity shall not exceed a certain rate when flowing two-thirds full depth.

Example 16.—An egg-shaped sewer is to discharge 110 cubic feet per second flowing full and its mean velocity flowing two-thirds full depth is not to exceed 5 feet per second? Find its dimensions and slope.

As a first approximation assume the velocity flowing full at 5 feet per second, then $\frac{110}{5} = 22$ square feet the area of egg-shaped sewer flowing full, and in Table 3 opposite this area the transverse diameter 4 feet 4 inches is found. Now with this diameter

the value of $c\sqrt{r}$ full depth $=116.0$
the value of $c\sqrt{r}$ two-thirds depth $=123.1$

therefore we may assume that the velocity of sewer flowing full is for 4 feet 4 inches, transverse diameter about 6 per cent. less than when flowing two-thirds full, that is, assuming the velocity at two-thirds depth 5 feet per second, the velocity at full depth will be about 4.7 feet per second. Substituting this velocity and also discharge in formula (6) $a = \frac{Q}{v} = \frac{110}{4.7} = 23.4$ the area

of egg-shaped sewer flowing full. In Table 3 the transverse diameter opposite this is 4 feet 6 inches, which is the diameter required of the egg-shaped sewer. At the same time that diameter is found look out the value of $ac\sqrt{r}$ which is 2770, substitute this in

formula (8) . $\sqrt{s}=\frac{Q}{ac\sqrt{s}}$

$$=\frac{110}{2770}=.039711.$$

In Table 2 the $\sqrt{s}$ nearest to this is .039715 opposite a slope of 1 in 634, therefore the dimensions of egg-shaped sewer are 4 feet 6 inches by 6 feet 9 inches and its slope 1 in 634.

Now in Table 4 the value of $c\sqrt{r}$ opposite transverse diameter of 4 feet 6 inches is 126.3, substitute this and also value of $\sqrt{s}$ above found in

formula (1) $v=c\sqrt{r}\times\sqrt{s}$ and we have

$v=126.3\times.039711=5$ feet per second, the mean velocity of sewer flowing two-thirds full.

Table 3.—Giving Values of a and r and also the Factors $c\sqrt{r}$ and $ac\sqrt{r}$ for Corresponding Transverse Diameters of Egg-Shaped Sewers, Flowing *full depth*, given in First Column.

These factors are to be used only where the value of n, that is the coefficient of roughness of lining of channel $= .015$, as in second-class or rough-faced brickwork, well-dressed stone work, foul and slightly tuberculated iron, cement and terra-cotta pipes with imperfect joints and in bad order.

Area of egg-shaped sewer flowing full depth $= D^2 \times 1.148525$.

Perimeter of egg-shaped sewer flowing full depth $= D \times 3.9649$.

Hydraulic mean depth of egg-shaped sewer flowing full depth $= D \times 0.2897$.

$$v = c\sqrt{r} \times \sqrt{s}. \quad Q = av = ac\sqrt{r} \times \sqrt{s}.$$

D = transverse diam. ft. in.		a = area in square ft.	r = hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
1	0	1.148	.2897	39.62	45.528
1	2	1.563	.3380	44.66	69.804
1	4	2.041	.3864	49.57	101.17
1	6	2.584	.4345	54.08	139.74
1	8	3.190	.4828	58.64	187.06
1	10	3.860	.5311	62.83	242.52
2	0	4.594	.5794	66.93	307.48
2	2	5.391	.6277	71.01	382.81
2	4	6.253	.6760	74.93	468.54
2	6	7.178	.7242	78.76	565.34
2	8	8.167	.7725	82.44	673.29
2	10	9.220	.8208	86.21	794.86
3	0	10.337	.8691	89.70	927.23

D= transverse diam. ft. in.		a = area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
3	2	11.517	.9174	93.25	1074.0
3	4	12.761	.9657	96.73	1234.4
3	6	14.069	1.014	100.1	1407.6
3	8	15.442	1.062	103.4	1596.7
3	10	16.877	1.111	106.6	1799.1
4	0	18.376	1.159	109.9	2019.5
4	2	19.940	1.207	113.0	2254.0
4	4	21.566	1.255	116.0	2501.4
4	6	23.258	1.304	119.1	2770.0
4	8	25.013	1.352	122.1	3053.8
4	10	26.830	1.400	125.0	3353.0
5	0	28.713	1.449	128.0	3675.6
5	2	30.660	1.497	130.7	4007.9

D= transverse diam. ft.	in.	a=area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
5	4	32.669	1.545	133.6	4364.9
5	6	34.743	1.593	136.4	4738.0
5	8	36.880	1.642	139.2	5131.7
5	10	39.081	1.690	142.0	5548.0
6	0	41.347	1.738	144.6	5980.3
6	2	43.676	1.787	147.3	6435.1
6	4	46.068	1.835	149.8	6902.6
6	6	48.525	1 883	152.5	7399.3
6	8	51.046	1.931	155.2	7920.6
6	10	53.629	1.980	157.7	8547.1
7	0	56.278	2.028	160.2	9015.7
7	4	61.764	2.124	165.0	10192
7	8	67.508	2.221	170.1	11482

D= transverse diam. ft. in.		a=area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
8	0	73.506	2.318	174.8	12852
8	4	79.758	2.414	179.6	14327
8	8	86.268	2.511	184.3	15898
9	0	93.030	2.607	188.8	17563
9	4	100.049	2.704	193.1	19323
9	8	107.324	2.800	197.5	21198
10	0	114.853	2.897	201.9	23191
10	6	126.625	3.042	208.3	26376
11	0	138.972	3.187	214.6	29822
12	0	165.388	3.476	226.8	37502

TABLE 4.—GIVING VALUES OF a AND r AND ALSO THE FACTORS $c\sqrt{r}$ AND $ac\sqrt{r}$ FOR CORRESPONDING DIAMETERS OF EGG-SHAPED SEWERS, FLOWING *two-thirds full depth*, GIVEN IN FIRST COLUMN.

These factors are to be used only where the value of n, that is the coefficient of roughness of lining of channel = .015 as in second class or rough-faced brickwork, well-dressed stone work, foul and slightly tuberculated iron, cement and terra-cotta pipes with imperfect joints and in bad order.

Area of section of egg-shaped sewer flowing two-thirds full depth $= D^2 \times 0.755825$.

Perimeter of section of egg-shaped sewer flowing two-thirds full depth $= D \times 2.3941$.

Hydraulic mean depth of section of egg-shaped sewer flowing two-thirds full depth $= D \times 0.3157$.

$$v = c\sqrt{r} \times \sqrt{s}. \quad Q = av = ac\sqrt{r} \times \sqrt{s}.$$

D = transverse diam. ft.	in.	a = area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge. $ac\sqrt{r}$
1	0	0.756	0.316	42.40	32.048
1	2	1.029	0.368	47.80	49.181
1	4	1.344	0.421	52.82	70.993
1	6	1.701	0.474	57.68	98.115
1	8	2.099	0.526	62.46	131.10
1	10	2.540	0.579	66.94	170.02
2	0	3.023	0.631	71.42	216.54
2	2	3.548	0.684	75.59	268.19
2	4	4.115	0.737	79.69	327.93
2	6	4.724	0.789	83.90	396.32
2	8	5.375	0.842	87.82	472.01
2	10	6.067	0.894	91.60	555.74
3	0	6.802	0.947	95.33	648.40

D = transverse diam. ft.	in.	a = area in square ft.	r = hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
3	2	7.579	1.000	99.10	751.08
3	4	8.398	1.052	102.7	862.41
3	6	9.259	1.105	106.2	983.24
3	8	10.161	1.158	109.7	1115.1
3	10	11.106	1.210	113.2	1256.1
4	0	12.093	1.263	116.5	1409.4
4	2	13.123	1.315	119.8	1572.1
4	4	14.192	1.368	123.1	1746.9
4	6	15.305	1.421	126.3	1932.7
4	8	16.460	1.473	129.4	2130.5
4	10	17.656	1.526	132.5	2338.6
5	0	18.895	1.579	135.5	2560.3
5	2	20.177	1.631	138.6	2795.9

D= transverse diam. ft. in.		a=area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
5	4	21.498	1.684	141.7	3045.5
5	6	22.863	1.736	144.6	3305.3
5	8	24.270	1.789	147.5	3578.9
5	10	25.718	1 842	150.3	3864.8
6	0	27.210	1.894	153.1	4165.3
6	2	28.743	1.947	155.9	4481.6
6	4	30.317	1.999	158.7	4811.9
6	6	31.933	2.052	161.5	5158.5
6	8	33.592	2.095	164.2	5516.6
6	10	35.292	2.157	166.9	5891.0
7	0	37.035	2.210	169.6	6283.5
7	4	40.646	2.315	174.8	7106.8
7	8	44.426	2.420	179.9	7993.0

D= transverse diam. ft.	in.	a=area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
8	0	48.373	2.526	184.9	8944.0
8	4	52.487	2.631	189.8	9964.1
8	8	56.771	2.736	194.6	11050
9	0	61.222	2.841	199.5	12213
9	4	65.840	2.947	204.2	13444
9	8	70.628	3.052	208.7	14743
10	0	75.583	3.157	213.3	16125
10	6	83.330	3.315	220.1	18342
11	0	91.455	3.473	226.8	20738
12	0	108.839	3.788	239.4	26060

Table 5.—Giving Values of a and r and also the Factors $c\sqrt{r}$ and $ac\sqrt{r}$ for Corresponding Diameters of Egg-Shaped Sewers, Flowing *one-third full depth*, given in First Column.

These factors are to be used only where the value of n, that is the coefficient of roughness of lining of channel $= .015$ as in second-class or rough-faced brickwork, well-dressed stone work, foul and slightly tuberculated iron, cement and terra-cotta pipes with imperfect joints and in bad order.

Area of section of egg-shaped sewers flowing one-third full depth $= D^2 \times 0.284$.

Perimeter of section of egg-shaped sewer flowing one-third full depth $= D \times 1.3747$.

Hydraulic mean depth of section of egg-shaped sewers flowing one-third full depth $= D \times 0.2066$

$$v = c\sqrt{r} \times \sqrt{s}. \quad Q = av = ac\sqrt{r} \times \sqrt{s}.$$

D = transverse diam. ft. in.	a = area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
1 0	0.284	0.207	30.41	8.637
1 2	0.387	0.241	34.38	13.303
1 4	0.505	0.276	38.16	19.269
1 6	0.639	0.310	42.23	26.986
1 8	0.789	0.344	45.39	35.815
1 10	0.955	0.379	48.74	46.546
2 0	1.136	0.413	52.09	59.173
2 2	1.333	0 448	55.29	73.696
2 4	1.546	0.482	58.58	90.568
2 6	1.776	0.517	61.58	109.37
2 8	2.020	0.551	64.49	130.26
2 10	2.280	0.585	67.46	153.80
3 0	2.556	0.620	70.48	180.14

D = transverse diam. ft.	in.	a = area in square ft.	r = hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
3	2	2.848	0.654	73.24	208.98
3	4	2.156	0.689	75.98	239.79
3	6	3.479	0.723	78.63	273.54
3	8	3.818	0.758	81.31	310.44
3	10	4.173	0.792	84.03	350.67
4	0	4.544	0.826	86.61	393.55
4	2	4.931	0.861	88.98	438.75
4	4	5.333	0.895	91.60	488.50
4	6	5.751	0.930	94.08	541.04
4	8	6.185	0.964	96.57	597.29
4	10	6.635	0.999	99.10	657.53
5	0	7.100	1.033	101.3	719.27
5	2	7.581	1.068	103.7	785.86

D= transverse diam. ft. in.		a=area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
5	4	8.078	1.102	106.1	856.67
5	6	8.591	1.136	108.3	930.54
5	8	9.120	1.171	110.6	1008.7
5	10	9.664	1.205	112.9	1091.0
6	0	10.224	1.240	115.0	1175.8
6	2	10.800	1.274	117.3	1266.4
6	4	11.391	1.309	119.4	1359.8
6	6	12.999	1.343	121.5	1458.1
6	8	12.622	1.377	123.7	1561.0
6	10	13.261	1.412	125.8	1668.8
7	0	13.916	1.446	127.9	1779.4
7	4	15.273	1.515	131.9	2014.1
7	8	16.693	1.584	135.8	2266.7

D= transverse diam. ft.	in.	a=area in square ft.	r=hydraulic mean depth in feet.	For velocity. $c\sqrt{r}$	For discharge $ac\sqrt{r}$
8	0	18.176	1.653	139.9	2542.7
8	4	19.722	1.722	143.7	2833.8
8	8	21.332	1.791	147.5	3146.2
9	0	23.004	1.859	151.3	3480.7
9	4	24.739	1.928	155.0	3834.7
9	8	26.538	1.997	158.6	4208.4
10	0	28.400	2.066	162.1	4604.7
10	6	31.311	2.169	167.5	5245.3
11	0	34.364	2.273	172.6	5932.1
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